High Strength Weight Reduction Materials

Basic Studies of Ultrasonic Welding for Advanced Transportation Systems

Background

The transportation industry is aggressively pursuing high-performance, energy-efficient vehicles that involve the increased use of lightweight and high-strength materials [i.e., aluminum (Al) alloys, composites, magnesium (Mg) alloys, and advanced high-strength steels]. Using these new materials presents significant technical challenges to the existing body-assembly joining processes such as the electrical resistance spot welding (RSW). There are a number of issues in applying RSW to aluminum sheet metals and coated steels. Furthermore, due to the metallurgical incompatibility, fusion welding of dissimilar metals (e.g., aluminum to steel) is generally very difficult, if not impossible.

Researchers at the Oak Ridge National Laboratory (ORNL) are working on the ultrasonic welding process, a solid-state joining process. This process addresses the transportation industry's critical need for lightweight and high-performance materials in heavy-duty vehicles. Additionally, ORNL researchers are evaluating the feasibility of using the ultrasonic process as a low-temperature metal powder compaction process.

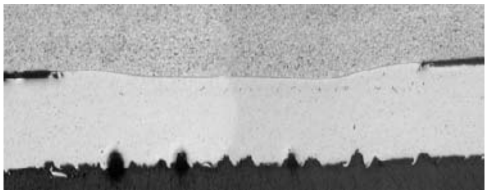

Figure 1. *UW bond between Al2024 and Al6061.*

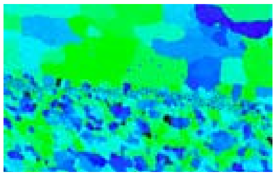

Figure 2. *Bonding interface microstructure.*

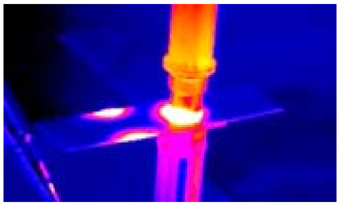

Figure 3. *Energy distribution during UW.*

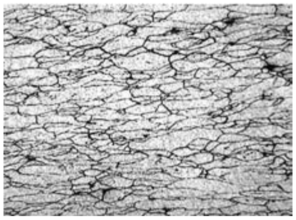

Figure 4. *Ultrasonic consolidation of Al powder.*

Technology

Ultrasonic welding (UW) uses high frequency mechanical vibrations to produce a solid-state metallurgical bond (weld) between metals. An electromechanical converter converts high-frequency electric current to mechanical vibrations. The mechanical vibration is typically at 20 to 40 kHz with an amplitude range of 5 to 50 mm. The power delivered to the

Benefits

- Provides a critical enabling joining process for increased use of high-performance lightweight material in heavy-duty vehicles.
- Offers high productivity due to its fast joining cycle and is extremely energy efficient due to its solid-state process nature.
- Enables low-temperature consolidation of materials produced by powder metallurgy.

workpiece ranges from several hundred to several thousand watts.

Thus far, Al, steel and Mg alloys have been successfully ultrasonic-welded. The feasibility of compaction and consolidation of metal powders has been demonstrated with Al powders. The joining of dissimilar metals (Al to Mg for example) is being investigated.

Status

Plans for continuation of this project include developing a clear understanding of acoustic wave propagation in the workpiece and its impact on weld quality, as well as developing an effective modeling capability to assist process optimization.

ORNL is pursuing opportunities for commercialization of this technology by identifying potential applications with its industry partners. ORNL plans to foster technology partnerships with other automobile/heavy truck manufacturers.

Figure 5. *Ultrasonic welding experimental apparatus.*

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